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# Reliable, Universal, Open Architecture for Card Access to Dispense Alternative Fuels

## NREL SUBCONTRACT REPORT

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Clean Cities
Alternative Fuel Information Series

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*Technical Support for*
*AFVs/Clean Cities Program*


# Reliable, Universal, Open Architecture for Card Access to Dispense Alternative Fuels



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# 1.0 Introduction

## 1.1 Project Background

The state of California continues to be in the forefront of implementing alternative fuels for transportation applications. Aggressive efforts to deploy alternative fuel vehicles (AFVs) in California have highlighted the need to provide adequate fueling stations and develop appropriate, user-friendly means to purchase fuel at the pump. Since these fuels are not typically provided by petroleum companies at conventional fueling stations, and acceptance of cash is often not an option, a payment method must be developed that is consistent with the way individual AFV operators are accustomed to purchasing automotive fuels—with a credit card. At the same time, large fleets like the California Department of General Services must be able to use a single fuel card that offers comprehensive fleet management services.

The Gas Technology Institute's Infrastructure Working Group (IWG) and its stakeholders have identified the lack of a common card reader system as a hurdle to wider deployment of AFVs in California and the United States. In conjunction with the U.S. Department of Energy's (DOE) National Clean Cities Program, the IWG has outlined a multi-phased strategy to systematically address the barriers to develop a more "open" architecture that's similar to the way gasoline and diesel are currently dispensed. Under the auspices of the IWG, survey results were gathered (circa 1999) from certain fuel providers, as a means to more carefully study card reader issues and their potential solutions. Pilot programs featuring card reader systems capable of accepting wider payment options have been attempted in several regions of the United States with mixed success.

In early 2001, DOE joined the National Renewable Energy Laboratory (NREL), the California Energy Commission (CEC) and the South Coast Air Quality Management District (SCAQMD) in a renewed effort to further develop a universal card reader access program. The immediate focus is on natural gas fueling stations—primarily compressed natural gas (CNG) in California. However, the ultimate intention is to apply the resulting advancements in open architecture card reader systems in stations dispensing other types of alternative transportation fuels across the United States.

## 1.2 Overview of the Problem

Card lock systems that control access to alternative fuel dispensers and record/process fueling transactions are available with many levels of sophistication. The suitability of a particular system for a given AFV operator is a function of many parameters. These include fleet size, specific fueling logistics (e.g., fueling on site vs. a remote location), type of billing system, types of records to be maintained, and other criteria. Theoretically, stations equipped with the most sophisticated card lock systems—networked card readers—can utilize a variety of payment cards ranging from bank debit, credit, and fleet cards. These systems may be more sophisticated than necessary for private stations but are generally considered essential for public-access stations.

Today's networked card reader systems typically offer limited payment options at "public" natural gas stations although that is where open access is needed most. There are approximately 240 CNG fueling stations in California—about half of which offer some degree of public access. According to the California Natural Gas Vehicle (NGV) Coalition, it would require seven or eight different account cards to access all of these public stations.[1] Typically, it's necessary to establish a separate credit card account with each fuel provider to fuel at public CNG stations, which vary in their hours of access, equipment, payment method, and on-site assistance. Approximately five of the public stations on the California NGV (CalNGV) list indicate that "major credit cards" will be accepted, but none allow use of these cards in the pay-at-the-pump mode used at mainstream gasoline stations.

[1] California Natural Gas Vehicle Coalition, information from Web site and *FuelingStations Directory*, September 2001.

Government entities have attempted to address this problem by requiring or providing incentives for open access stations. In California, the state Energy Commission and other government agencies often require "universal" card reader systems when funding programs are used to support fueling stations. Arizona requires all government-funded natural gas stations to install a card reader system that is compatible with VISA or MasterCard. While such requirements are helpful in moving the industry toward open access stations, they are vaguely defined and not yet practical enough to fully enforce.

Modest progress toward more "user friendly" point-of-sale (POS) options has been made. Card reader vendors that have offered some degree of open access at California's CNG stations include EJ Ward, AutoGas, GasBoy, and Petro Vend and Multiforce. Petro Vend claims to offer CNG card reader systems that are compatible "with a wide selection of commercial fueling networks" making operation of CNG dispensers as user friendly as gasoline and diesel dispensers.[2] EJ Ward has teamed up with the California NGV Coalition and Long Beach Gas & Electric Department to provide a common statewide card link that accepts certain cards issued by gas utilities, fuel providers, fleet card companies, and fleets. The EJ Ward system has been among the most advanced for having fully programmable, software-driven network capability. This system has been part of the FuelNet program, which is described further in Section 2.0.

To achieve true universal access major investments are required to develop and deploy software programs and improve hardware commonality. With utilities constrained in using ratepayers' money for such investments, private entrepreneurs must lead the way. A major barrier has been the lack of a compelling profit motive for the private sector to offer wider card reader access at today's typical public access CNG fueling station. This is because such stations tend to dispense low volumes of fuel, due to the absence of an anchor fleet, such as a transit district, refuse hauler, or taxi service. In addition, the transaction fees associated with the use of major credit cards at public-access CNG stations are simply not cost effective in the current low-volume market of alternative transportation fuels (see section 2.0).

Presumably to help enhance profitability, several turnkey natural gas fuel providers have begun to invest capital in conjunction with fuel card companies to improve card reader commonality at CNG stations in California. Pinnacle CNG is expanding its system to "support all major credit cards and allow CNG stations to operate just like self-serve gasoline stations." Pinnacle's new Pay-at-the-Pump 120 dispenser was introduced at its Lancaster, Calif., CNG station, in fall 2001.[3] Trillium USA's fueling cards provide 24-hour access to many private stations as well as all Trillium network stations. According to Trillium USA brochures, most commercial fleet fuel cards can also access Trillium USA's stations, making it "as convenient to fill up with CNG as it is to fill up with gasoline or diesel." VISA and Voyager have teamed in a joint partnership to process all fuel transactions, though the cost to upgrade existing card readers would be significant.[4] Pickens Fuel Corporation[5] recently began working closely with Multiforce to develop new software that will allow its CNG stations to accept VISA and MasterCard. In fact, according to company literature, Multiforce's Fuelforce software system will already accept Voyager, VISA, MasterCard, Wright Express, CFN, and PHH, among other types of cards.[6]

Still the problem remains: Each CNG customer in California must carry multiple fueling cards to obtain natural gas fuel at a variety of stations. Few CNG stations actually accept common credit cards such as VISA and MasterCard; those that do accept credit cards rarely offer a pay-at-the-pump option, unlike most gasoline stations. While there are no major technical barriers to enabling more user-friendly POS options at CNG stations, progress continues to be slow. Some industry representatives have stated that

[2] Petro Vend Web site (http://www.petrovend.com/).

[3] Drew Diggins, Pinnacle CNG, interviewed in *CalNGV News*, September 3, 2001.

[4] Greg Vlasek, California NGV Coalition, personal communication to Jon Leonard, March 2000.

[5] Pickens Fuel Corporation recently merged with eFuels by BCG to become ENRG.

[6] Multiforce Systems Corporation, *Product Summary on FuelForce*, provided to ADLittle in March 2001.

this will be the case as long as natural gas remains a small fraction of the transportation fuels market. Others are taking a more pro-active approach and working to advance systems that can closely mirror payments and billing systems used at today's gasoline stations. This issue and possible solutions are addressed in section 2.0.

A second barrier to broader expansion of the CNG infrastructure is that some NGV users perceive CNG card reader systems to be significantly less reliable than their counterparts at gasoline and diesel stations. This issue is addressed in section 3.0.

### 1.3 Project Objective

The objective of the work performed under this task order was to develop a draft set of performance requirements for open-architecture card reader systems for CNG stations *with equivalent reliability and user-friendliness to gasoline systems*. The desired end result is to provide input for a government request for proposals (RFP) that includes clear, obtainable design and development criteria, towards which bidding contractors can strive to achieve. The defined sets of requirements are intended to address a reliable card access architecture that can be developed and applied not only in California but nationwide.

## 2.0 Assessment of Open Access Card Reader Systems

In addition to examining existing product literature and technical papers, the Arthur D. Little (ADLittle) team used three major sources of information to draft a set of standards for open access card reader systems. These sources were: 1) industry input obtained at a workshop held in California on March 16, 2001; 2) site visits to locations where work is underway to resolve the problem; and 3) telephone calls to individuals involved with similar programs in Atlanta, Baltimore, Denver, and Dallas-Ft. Worth.

### 2.1 Government-Industry Workshop

#### 2.1.1 Overview of Workshop and Objectives

ADLittle planned, implemented and facilitated a workshop in California to discuss the current state-of-the-art of card reader systems for alternative fueling stations, and actions that are needed to achieve a system with greater degrees of open access. The workshop was conducted on March 16, 2001, at the SCAQMD headquarters in Southern California, capping a full week of meetings related to the NGV industry. Attending the workshop were representatives from the sponsoring government agencies, fuel providers, fleet managers, vendors of card reader hardware, and software providers. Complete lists of attendees and invitees are provided in Tables 1 and 2.

**Table 1. List of Attendees at March 16, 2001, Workshop**

| Name | Organization/Company |
|---|---|
| Jon Leonard | Arthur D. Little–Acurex Environmental |
| Mike Jackson | ADLittle–Acurex Environmental |
| Robb Barnitt | ADLittle–Acurex Environmental |
| Richard Parish | NREL |
| Carol Hammel | NREL |
| Dennis Smith | DOE |
| Peter Ward | California Energy Commission |
| Jim Folkman | California Energy Commission |
| Stan Sinclair | Southern California Gas |
| John Featherston | E.J. Ward |
| Mike Eaves | Southern California Gas |
| Sean Turner | California Natural Gas Vehicle Coalition |
| David Haradon | Pickens Fuel Corp. |
| Denis Ding | Pickens Fuel Corp. |
| Mickey Bouchet | AutoGas Systems |
| Kip Carlyle | AutoGas Systems |
| Tom Alexander | Pacific Gas & Electric |
| Steve Dickson | Dickson Company |
| Ray Meyers | U.S. Bank Voyager Fleet Systems |
| Karen Sagen | Gladstein & Associates |
| Greg Vlasek | Pinnacle CNG Systems |
| Reb Guthrie | Fuel Solutions |
| Richard Remillard | Fuel Solutions |
| Tom Bates | Multiforce Systems |
| Ray Riddel | Multiforce Systems |

**Table 2. Invited but Unable to Attend**

| Name | Organization/Company |
|---|---|
| Andrew Littlefair | Pickens Fuel Corp. |
| Steve Bartlett | Fleetstar/Applied LNG Technologies |
| Rick Gamble | Pacific Cryogenics |
| Stan Taylor | Blue Fuels Group |
| Jan Hull | Trillium USA |
| Ken Kelley | Applied LNG Technologies |
| Lisa Wunder | Clean Cities Representative, Los Angeles Area |
| Juliet Burdelski | Kingdom Group |
| Tim Bow | California Department of General Services (Fleet) |
| Norm Stone | Pacific Gas and Electric |

The workshop began with a presentation by Jon Leonard of ADLittle, providing an overview of the problems and the specific objectives of the various government agencies in developing an RFP. Appendix A provides copies of Leonard's PowerPoint presentation.

### 2.1.2 Industry Input at Workshop: Status of Card Reader Systems

Following Leonard's opening presentation, representatives from NREL, CEC, DOE, ADLittle, and Fuel Solutions joined industry representatives in a round-robin discussion. Representatives from the three card reader companies, Multiforce, AutoGas, and EJ Ward, briefly described past and current work to develop open access systems and collaborations with various fuel providers. Pickens Fuel Corporation described in detail its current collaboration with Multiforce to develop new software enabling commercially viable use of VISA and MasterCard at CNG stations. The point was made by industry representatives that, analogous to the use of gasoline fuel cards, two proprietary fuel cards for natural gas fuel (e.g., Pickens Fuel Corporation and Pinnacle CNG) are not likely to be accepted at the same station. This is essentially because such companies are not willing to share proprietary databases with competitors due to the strategic market importance of such information.[7] However, Pickens Fuel Corporation representatives strongly emphasized that their company is willing to work with the industry as a whole to make software and hardware advancements available for industry-wide use.

Industry representatives at the workshop stressed that the hardware attributes and functional capabilities of modern fuel management systems (FMS), including those used at California's CNG stations, are generally comparable. Today's card readers from Multiforce, EJ Ward, and AutoGas can read most cards that use magnetic strip systems. These devices are relatively inexpensive components of CNG dispensers (about $100 per unit[8]).

Marconi Commerce Systems (formerly Gilbarco), a world-leader in sales of fuel dispensers and other fueling-related components, manufactures the most commonly used automotive fuel dispenser technology in America. A typical state-of-the-art gasoline dispenser is the Marconi Advantage® MPD 3-Grade Blender with Marconi's Card Reader in Dispenser (CRIND®), which allows the use of fuel cards and

[7] While this point was adamantly made at the March 2001 workshop by Pickens Fuel Corporation, Pinnacle's Drew Diggins stated in an interview with *CalNGV News* (September 3,2001) that greater cooperation is needed among fuel providers to recognize each other's fueling cards. He noted that inter-company agreements to handle billing and collection are feasible, and stated that: "Pinnacle will guarantee direct payment" to another company if its card is used outside the Pinnacle system.

[8] Source: Drew Diggins, Pinnacle CNG, in *CalNGV News* interview, September 3, 2001, issue. This ballpark figure was also corroborated by workshop attendees.

major credit cards. It is the software capabilities of fuel dispensers and card readers that primarily vary among the many companies that use Marconi products. The type of software used and the level of sophistication largely depend on customer needs and other market-driven factors. Although there are no major technical barriers, the integrated hardware-software POS systems of today's CNG dispensers are significantly less "user friendly" compared to gasoline systems because market demand has not justified the incremental costs.

This point is well illustrated in the method currently used to produce and market state-of-the-art CNG dispensers based on Marconi's ubiquitous gasoline dispensers. Marconi has partnered with Greenfield Compression, Inc. (a wholly owned subsidiary of Sulzer Burckhardt) to outfit its conventional liquid-fuel dispensers with CNG-specific hardware. Under this agreement, Marconi ships a standard Advantage® Series dispenser cabinet and electronics to Greenfield for conversion. Greenfield then installs CNG-compatible piping and hoses, a gaseous fuel flow meter, filters, a rotary valve, a programmable logic chip, and a new air purging system for the lower housing. According to Marconi literature, the Greenfield conversion for its Advantage® product enables dispensing of CNG "via a familiar gasoline-style fuel dispenser." As an option, Greenfield will install Marconi's CRIND® feature that enables the user to pay at the pump with a fueling card or major credit card. However, in the current market for CNG dispensers, there appears to be very limited demand for this level of POS sophistication. The photo at the right shows a Marconi Advantage® dispenser that has been converted for CNG by Greenfield Compression but without the CRIND® feature.[9]


Marconi's Advantage® Series fuel dispenser, converted for CNG by Greenfield Compression.
(Photo from Marconi Web site, http://www.marconi-commerce.com/.)

### 2.1.3 Barriers to Universal Card Reader Systems

As highlighted in detail by ADLittle at the March 16 workshop (see slides in section 5.0), barriers to truly open access card reader systems fall into four categories: technical, financial, confidentiality, and business/marketing. A fifth category that could be added is safety/liability. Table 3 provides an overview of these barriers.

[9] According to Hank McElvery of Greenfield Compression, in a few situations, CNG dispensers have been equipped with the CRIND feature with standard two-wire communication into gas stations or convenience stores. However, due to the added costs and associated fees, this is not the usual practice.

**Table 3. Overview of Barriers to Universal Access CNG Card Reader Systems**

| Types of Barriers | Examples of Specific Barriers | Comments/Recent Developments |
|---|---|---|
| Technical | • Incompatible card readers among station vendors<br>• Communication issues in software and hardware<br>• Lack of any "canned" CNG-specific software | • Vendors are making significant advancements with standardized software |
| Financial | • Granting customer credit can be risky for fuel providers in low-volume market<br>• Transaction fees are disproportionably high | • Some vendors currently require prepayment for card users, due to credit risk |
| Confidentiality | • Proprietary cards each involve a separate database, and data sharing may require explicit permission by each account holder | • Most fuel providers are extremely reluctant to share databases with competitors |
| Business/ Marketing | • Fuel providers want to retain ability to provide special rates and/or services to their customers | • Partially resolvable with third-party cards |
| Safety/Liability | • Lack of mechanism to assess status of VISA/MasterCard customer's training<br>• Need for automated mechanism to query customers and lock out fueling if training cannot be verified | • Workshop participants varied in assessments of this barrier's seriousness |

### 2.1.4 Workshop Conclusions and Recommendations

Based on input received at the workshop, current software limitations present the biggest barriers and will cost the most to overcome. In many systems, the software or database in the site controller may not recognize or properly interpret all card identification numbers. For example, at some sites, the controller will read and accept a foreign card for which no billing arrangements have been made. In this case, the site controller records the transaction and card number, but the transaction may not be billable because the card number is not linked to an account. If the software is configured correctly and equipped with telecom interface, the Fuel Management System (FMS) can communicate with outside billing hosts to discriminate between valid and invalid card numbers, authorize customers and record and bill transactions. Such software upgrades entail significant costs that can be hard to justify for a relatively low return on investment.

For those CNG fuel management systems currently configured to accept bank credit cards, transactions can be cost prohibitive. Because the NGV customer base is currently so small, bank credit card fees can be range from $1.50 to $2.50 per transaction for a purchase involving just 10 gasoline gallon equivalents of CNG fuel.[10] For high-volume businesses, such as those that sell gasoline, credit card transaction fees are proportionally much smaller and readily absorbed by the vendor. Also, logistically the FMS must be capable of alerting customers of any fees prior to the transaction and ensure that the fee is properly recorded and added to the customer's fuel bill. These capabilities require specialized software and administrative costs.

Workshop participants offered specific recommendations on how to best proceed. It was agreed that open access fuel management systems can be installed most easily at new fueling stations, using modern equipment and a moderate amount of software and interface development between the FMS and the

[10] This figure was offered by various industry representatives at the March 16 workshop. Pinnacle's Drew Diggins estimated the price increase for CNG users when using VISA or MasterCard to be from $.06 to $.10 per GGE. At that rate, the fee on a 10 GGE fill will be $.60 cents to $1.

affiliated fueling network and bank credit card company. However, retrofitting the large installed base of fuel management systems at existing CNG fueling stations to open access would require moderate to substantial modifications. Multiforce Corporation has made significant progress in linking its system for open access to existing site controllers, and has initiated a program with Pickens Fuel Corporation to retrofit certain stations in Southern California. While this approach appears to be technically feasible, warranty issues for a hybrid site composed of pieces of equipment from competing vendors[11] could be difficult to address.

A consensus of workshop participants was that more user-friendly, open access card reader systems can be deployed by the CNG fueling station industry through continued development efforts by industry and strong assistance from government agencies. For both new sites and retrofit installations, it was agreed that it would be best for the industry to have more than one FMS vendor with open access systems. This will help to assure adequate price competition and good system integration, warranty coverage, and service parts availability for retrofit packages.

## 2.2 Site Visits and Further Fact Finding

The ADLittle team conducted additional research to further define the issues and barriers associated with an open architecture card access system. In early March 2001, Leonard and Richard Remillard of Fuel Solutions met with staff from Pickens Fuels Corporation at its headquarters in Seal Beach. During this meeting, Barbara Johnson and Denis Ding described Pickens' efforts with Multiforce to develop an advanced open access card reader system for CNG stations that can accept VISA and MasterCard. Details were learned about Pickens' proposal to the SCAQMD and the CEC to retrofit all Pickens stations in Southern California with this system.[12] This program is discussed in more detail below.

As a follow-up to this meeting, ADLittle staff attended the official "ribbon-cutting" ceremony for a new CNG station showcasing the recent Pickens-Multiforce collaboration. Located in downtown Los Angeles with several major anchor fleets,[13] this station includes a public-access side equipped with a single, state-of-the-art CNG dispenser. The Multiforce card reader is located nearby on a separate pedestal. According to Pickens personnel, the card reader at this beta station has been equipped with all the necessary hardware and software to accept mainstream credit cards in addition to the standard Pickens and SoCal Gas cards. This feature was not operative on opening day (March 2001), but Pickens staff indicated that activation is expected in the near future.

ADLittle staff followed up with PFC to assess the status of this important development. In April 2001, Pickens staff indicated that arrangements to add the VISA and MasterCard options were nearly complete, with a few more bank-related legal issues to resolve.[14] A check of Pickens' Web site in October 2001 indicated that "by end of May 2001" the downtown Los Angeles station was supposed to accept "VISA, MasterCard, American Express, and Voyager" cards. Of 29 Pickens-owned natural gas stations in California listed on the Web site, only the downtown Los Angeles station is designated for such universal access.[15] In early October 2001, ADLittle confirmed that the Pickens beta site was technically ready for full implementation of multiple card access.[16] ADLittle staff visited the station in late October to assess

[11] Southern California stations will mostly involve retrofits of EJ Ward card reader systems, while Northern California retrofits will tackle Tech 21 systems.

[12] In early 2001, Pickens submitted its proposal to SCAQMD and CEC to retrofit approximately 30 existing CNG stations with the Multiforce card reader systems that can accept multiple fueling cards and even mainstream credit cards. Pickens and Multiforce are moving forward with this effort, and a contract with the SCAQMD for funding appears imminent.

[13] According to Pickens Fuel Corporation' Dave Haradon, users for this CNG station include Yellow Cab, LA Taxi, SuperShuttle, Prime Time (shuttle), and the City and County of Los Angeles.

[14] Dave Haradon Pickens Fuel Corporation, personal communication to Robb Barnitt of ADLittle, April 24, 2001.

[15] Pickens Fuel Corporation (now ENRG) Web site (http://www.pickensfuel.com/index.html). October 25, 2001.

[16] Hank McElvery, Greenfield Compression, personal communication to Jon Leonard, October 2, 2001. McElvery confirmed this with MultiForce.

the actual status. It was noted that no signage on the dispenser (or anywhere else at the station) specified which fueling cards could be used in the Multiforce card reader. ADLittle staff attempted to purchase fuel using VISA and MasterCard credit cards without success. As of the final writing of this report, the schedule for acceptance of credit cards is unknown. Part of the delay may involve recent negotiations among the various parties and Brennes-Jones[17] to set up merchant agreements—a– positive development that will ultimately benefit the process.[18]

In addition to a business plan to build new stations similar to this beta station, Pickens and Multiforce intend to retrofit as many as 75 CNG stations in the western United States during the next few years. The SCAQMD-funded program will soon undertake the first of these retrofits. The basic upgrade will replace EJ Ward or Tech 21 card reader systems with Multiforce systems on stand-alone pedestals. While not yet actually done, Multiforce also plans to retrofit some stations with its card reader system installed into Marconi dispensers upfitted for CNG by Greenfield Compression. Once configured for the Multiforce controller to "talk" to the Greenfield dispenser, consumers will have a true pay at the pump option that accepts a whole host of cards just like a typical urban gasoline station.[19]

### 2.3 Assessments of Related Activities Outside California

Another key objective of the ADLittle team was to obtain information about pilot programs outside California that have attempted to deploy universal card reader systems. Using contacts provided by DOE staff, ADLittle contacted several key organizations and people in Atlanta, Baltimore, Dallas, and Denver. Table 4 lists the names of the individuals and organizations that were contacted. Discussion of findings and results are provided by city/program.

[17] The Brennes-Jones Group, Inc., has bank sponsoring agreements with U.S. Bank, Minneapolis, and Moneris Solutions/Harris Bank, Chicago.

[18] Tom Bates, Multiforce Corporation, personal communication to Jon Leonard, October 29, 2001.

[19] This plan was separately conveyed to Jon Leonard by Hank McElvery of Greenfield Compression, October 2, 2001, and Tom Bates of Multiforce, October 29, 2001.

**Table 4. Individuals Contacted by ADLittle to Provide RFP Insight**

| Contact Name | Organization | Dates Contacted | Result |
|---|---|---|---|
| Linda Smith | Atlanta FuelNet | 4/17/01 | Input provided on Atlanta's FuelNet |
| Tom Tebockhorst | Atlanta Gas Light Company | 4/18/01 | Input provided on Atlanta's FuelNet |
| Leo Thomason | Thomason & Associates | 4/17/01 | Input provided about generic problem and potential solutions |
| Tom King | Edwards & Kelcey | 9/25/01 | Input provided on Baltimore's BG&E station network |
| Chuck Nolan | Baltimore Gas & Electric | 4/17/01 | Input provided on Baltimore's BG&E station network |
| Jerod Hightower | LoneStar Gas (now TranStar Energy, part of Blue Energy) | 4/11/01<br>4/17/01 | No response |
| Jim Moore | Blue Energy | 9/24/01 | No response |
| Paul Nelson | Natural Fuels/Blue Energy | 9/24/01 | Input provided on Denver and Dallas-Ft. Worth station network |

### 2.3.1 Atlanta's FuelNet Program

In the mid 1990s, as part of a nationwide CNG pilot project, Amoco chose Atlanta as the site for its largest network of public CNG stations. However, by December 1996 Amoco had discontinued its CNG program nationwide and closed all Atlanta's stations, effectively stranding many small fleets and private NGV users without access to fuel. The Atlanta FuelNet program was initiated to provide these NGV users with fuel. It opened up access to previously private or limited-access CNG stations. To accomplish this, a card reader system that could recognize "universal" types of fueling cards and credit cards was required.

The FuelNet program was originally funded by stakeholders such as the Gas Technology Institute (GTI), DOE's Clean Cities State Energy Program (SEP), Atlanta Gas Light Company, the State of Georgia, and FuelNet users. Targeted for initial deployment were fast-fill stations using the EJ Ward card reader system with adequate throughput capacity, which could most easily be modified for open access. The main focus was hardware modifications, such as installing compatible card readers with dial-up modems, but FuelNet also involved software parameters. EJ Ward uses a Windows NT operating system and works by holding transactions in Random Access Memory at the card reader for downloading by a central computer, which stores the information in a database and generates billing statements.

As noted in Table 6, ADLittle contacted Tom Tebockhorst of the Atlanta Gas Light Company and Linda Smith of Atlanta FuelNet to learn more about the program status and the lessons learned. Tebockhorst noted that the underlying dynamics of universal card reader access are market-driven. He believes that the best approach is the one taken by FuelNet, i.e., initially seeking compatibility of card readers with a large fleet fuel company, such as Wright Express or Voyager. Smith described how the FuelNet program has helped to advance common card reader systems, and has facilitated better understanding of some of the unique problems that can occur with CNG stations. For example, FuelNet's targeted stations were owned by a combination of individual station owners and the local gas utility company. She described some of the legal and logistical issues that were encountered and addressed. Originally, the approach was to approve each fueling card prior to activation and obtain signed agreements between each customer and station owner. Since these arrangements were challenging to implement, the FuelNet program used a PIN

system for each card, with card readers programmed to accept only certain personal identification numbers (PINs). This allowed the acceptance of several cards; all billing was conducted using FuelNet.

Smith elaborated on the approach FuelNet is now taking, which includes collaboration with Wright Express and others[20] to enable the use of a single fuel card for all CNG transactions. Funds allocated by the State of Georgia cover all FuelNet fees associated with processing several different fueling cards. Smith noted that the effort specific to Wright Express has been underway since mid 2000, and said it has been a relatively slow, expensive process to integrate EJ Ward card readers and Wright Express into a workable system. However, Smith indicated that the FuelNet stakeholders are willing to invest in the program to make it work. She noted that FuelNet is growing at a steady pace of about two to three new agreements per month. One general problem is that Voyager and Wright Express continue to view the natural gas fueling business as being too small to warrant major resource commitments.

Smith supported the idea of major credit card compatibility at CNG fueling stations in California. Similar to the conclusion reached in the March 16 workshop, she indicated that the best result would be 100% accessibility for MasterCard and VISA in tandem with fleet cards such as Voyager or Wright Express. She cited the following as the biggest issues needing resolution for implementation of an open-architecture card reader system: contract control, fuel taxes, and daily identification of fuel price. Other suggestions, points, and recommendations made by Smith are listed below.

- Good customer training is important, including the need for ongoing efforts to accommodate frequent driver turnover. However, there is no established training protocol, and, in practice, it can be difficult to ensure training.

- Fuel taxes are typically unknown at the time of fuel sale. For example, many government entities are partially tax-exempt. When the price on the pump is not the customer's final cost, it creates additional work at the time of billing and additional confusion on the part of the customer.

- Using a Web site to communicate current fuel prices to customers would be one way to address the above problem. The Web site should post prices and include a directory of stations that accept the customer's fuel card. Additional potential features could allow online payment options for those with fleet card agreements.

- Public-access fueling stations should be open at least 8 a.m. to–5 p.m., and preferably 24 hours a day. A toll-free phone number should be posted at the fueling station if a customer has problems.

The FuelNet program was conceived as a pilot effort with the intention that, if successful in Atlanta, it could be expanded to other CNG markets around the country. For the last several years, the California NGV Coalition has been working with DOE and certain California marketers to integrate California stations into a similar FuelNet type system. Originally, it was hoped that the program would be operational in California by 1997, but it has not progressed beyond a small pilot program involving EJ Ward and various California partners.[21]

### 2.3.2 Colorado and Texas Programs

ADLittle conducted a telephone interview with Paul Nelson[22] to assess the "lessons learned" about card reader systems in two affiliated key CNG station networks of the western United States. These are the

[20] Wright Express is the predominant fleet fueling card in the Atlanta area, but Voyager has also been involved in discussions.

[21] EJ Ward Web site (http://www.ejward.com/cng.htm), quoting Greg Vlasek of Cal NGV Coalition, March 2000.

[22] According to *TranStar News* (Volume 1 Number 1, Q4 2000), Paul Nelson is Blue Energy's founder and President/CEO, as well as General Manager of Natural Fuels Corporation. He was reached at his Denver office of Natural Fuels.

Natural Fuels Corporation[23] network in Colorado and Wyoming and the Blue Fuels Group[24] network in the Dallas-Ft. Worth area.

**The Natural Fuels Program in Colorado and Wyoming:** Natural Fuel Corporation operates approximately 37 public access CNG fueling locations in Colorado and Wyoming. Partners include Total Petroleum, Xcel Energy of Colorado, Peoples' Natural Gas, K.N. Energy, Greeley Gas Company, City of Colorado Springs, and Cheyenne Light, Fuel & Power. In addition to these public stations, many private fueling stations are operated, owned, and/or maintained in Colorado and Wyoming. Roughly half of the CNG stations in this network are located in the Denver metropolitan area. Other stations tend to be located to the west along the Interstate-70 corridor, and to the north and south along Interstate-25. [25]

Natural Fuels Corporation describes itself as "an OEM packager for natural gas compressors, as well as gas handling panels, storage cascades, and dispensing equipment." Under the Colorado-Wyoming network, all public-access CNG stations accept Natural Fuels' proprietary fueling card. Tech 21 card readers are used at these stations, which can be co-located with gasoline pumps or stand-alone natural gas stations. Most or all dispensers are weights-and-measures approved, and utilize the Micro-Motion meter system.

In the Natural Fuels public fueling network, each system generates fueling reports and initiates billing information at the card reader. These systems currently are not set up to accept fleet credit cards such as Voyager or Wright Express, or consumer credit cards such as VISA and MasterCard, because the higher costs of these options are currently not justified by customer needs. First, there would be an added cost of the capability for calling to a third-party clearinghouse that verifies credit card transactions. Nelson estimates that approximately 2% to 3% of station revenue would be lost to such transaction fees. Nelson indicated that the hardware and software costs to make the Denver system capable of taking a widely available fleet card such as Voyager would be about $5,000 to $10,000 per station.[26] To date, there has not been a need for such a system in Colorado that would justify the added costs. According to Nelson, the Colorado-Wyoming program is dominated by NGVs used locally by fleets and individuals, obviating the need for card access beyond the proprietary Natural Fuels card.

Nelson made it clear that as the CNG market expands and NGV use becomes more mainstream, his company will continually revisit the relative costs and benefits of incorporating a more universal-access card reader system. He stressed that the barriers are not technical—simply a matter of current customer needs in the Natural Fuels Program and vendors maximizing returns on investments.

The Blue Fuels Program in Dallas-Ft. Worth: The Blue Fuels Group has been instrumental in developing and commercializing a natural gas infrastructure in the Dallas-Ft. Worth metropolitan area. Both CNG and liquefied natural gas (LNG) applications are supported for both public and private sector customers. To date, some 28 CNG stations throughout the Dallas-Ft. Worth area have been designed and built, as well as two large LNG stations for Dallas Area Rapid Transit (DART).[27] The current number of public-access CNG stations in this system is approximately 20.

Blue Fuels describes itself as "a system integrator rather than a packager or manufacturer" of natural gas fueling equipment. As such, it specializes in selecting and integrating equipment that is best suited for a particular application. Blue Fuels has developed computer software for automated control of natural gas fueling stations that's complete with onsite or remote PC interface capabilities. The software has the

[23] Natural Fuels Corporation is a joint venture between Xcel Energy of Colorado and Colorado Interstate Gas Company.

[24] TranStar Energy and Natural Fuels Corporation are part of the Blue Fuels Group, L.P. (formerly known as LoneStar Energy Company).

[25] Information was obtained from the Natural Fuels Web site (http://www.naturalfuels.com).

[26] A recent development that may help reduce costs is that Voyager is reportedly on the verge of becoming its own settlement house.

[27] From Web site for Blue Fuels Group (http://bluefuels.com/).

capability to develop and install customized software/hardware control systems for new fueling facilities or perform upgrades to existing natural gas systems.

According to Nelson, most stations in the Dallas-Ft. Worth system are equipped with AutoGas 144 card readers that utilize AutoGas SMS (Microsoft's Systems Management Server). Some deployment of Multiforce card reader systems has also occurred. However, this Dallas-Ft. Worth network currently accepts only TranStar's proprietary fueling card and certain other fueling cards (e.g., FINA). While "capable" of being adapted, today the Dallas-Ft. Worth network is not set up to accept mainstream fleet credit cards (e.g., Voyager, Wright Express) or consumer credit cards (VISA, MasterCard). As in the Colorado-Wyoming case, the card reader software system calls out in the early morning hours to download all of the previous day's fueling transactions. This generates a monthly fueling report and invoice for the customer.

Nelson summarized that, similar to the Colorado-Wyoming network, current use characteristics of the Dallas-Ft. Worth CNG station network do not require a more "universal" card reader access. The limited need for such access simply does not justify the added costs to the vendor or the customers. Barriers in the Dallas-Ft. Worth network are not technical–any existing or new CNG station can be made compatible with fleets cards (Voyager, Wright Express) or consumer credit cards (VISA, MasterCard).

If a single card access is desired, Nelson believes the most cost-effective approach would be to utilize a company like Voyager or Wright Express. He noted that vendors that are not willing to share customer data need a third party such as Voyager or Wright Express to maintain proprietary databases (a result of multiple card access to stations with proprietary cards). Nelson said that a national clearinghouse for data sharing is needed that does not involve credit issues or clearance.

### 2.3.3 Baltimore Gas & Electric's Program

Baltimore Gas & Electric (BGE) provides a CNG station network in the greater Baltimore area. In the past, BGE has obtained DOE funding to help defray the costs associated with developing an open card reader system at these stations. The technical elements of this effort involved the addition of new hardware (e.g., magnetic card readers and modems) in certain stations, and the modification of software programs.

The intention was for these upgrades to allow CNG station users to link with Paymentech Merchant Services, one of the nation's largest bankcard transaction processors. Paymentech could then authorize transactions and settle payments on fleet credit cards used in BGE's fueling network. Among the fueling card options that Paymentech routinely handles for pay-at-the-pump gasoline stations are AutoGas, Wright Express, PHH, Voyager, MasterCard Fleet, and Gascard. Paymentech authorizes a user then initiates the transaction and dispenser operation. The intention was for this system to track all BGE fuel transactions using Wright Express and PHH cards.

In September 2001 ADLittle contacted people familiar with the BGE network to assess progress and "lessons learned." Today approximately 10 CNG stations are operative in the greater Baltimore area. All stations offer access to CNG fuel 24 hours a day, seven days a week, but transaction options at unattended stations are limited to special fueling cards. At least three of the CNG stations are "co-located" with gasoline and diesel at Crown Petroleum stations and offer full public access. These attended Crown-operated stations are capable of accepting consumer credit cards, but the customer cannot pay at the pump during such a transaction. The other CNG stations are operated by BGE on their own property. These

stations are also open to the public but require either a PHH fueling card[28] or a fuel contract with BGE. The Wright Express option has not been implemented.

Since the mid 1990s, BGE has been upgrading CNG stations with "extremely capable" Multiforce fuel management systems in this fueling network. In theory, these card readers can accept multiple payment options. As of yet, Multiforce card readers used in the BGE system do not offer the same complete full point-of-sale capabilities of a modern gasoline station, however. As is the case described for the aforementioned CNG station networks, fuel throughput has not yet reached a volume that justifies the expenses for full credit card access.

Washington Gas has helped to deploy 18 CNG stations in the greater Washington, D.C., metro area, which includes parts of Maryland and northern Virginia. Most of these stations offer limited public access with a Washington Gas card key. While a few are co-located at gasoline stations and offer the use of major credit cards and/or cash, there is no pay at the pump option for these transactions.[29]

### 2.3.4 Lessons Learned from Other Programs

Clearly some progress has been made in the programs described above in Atlanta, Baltimore, Denver, and Dallas-Fort Worth. Card reader systems are being deployed that have the capability to offer CNG consumers expanded POS purchase options beyond proprietary fueling cards provided by station vendors. In Atlanta, for example, the FuelNet program is now working with Wright Express, and a mechanism has been established for the State of Georgia to pay transaction fees. This program is moving forward but is not yet fully operational. In Baltimore, older card reader systems upgraded with Multiforce technology now offer the capability at certain stations to accept PHH fleet cards as well as BGE's proprietary fuel card. Other cities, such as Philadelphia, are seeking financial and brokering partners to open up access at CNG stations.

Despite the progress made, NGV users in Atlanta, Denver, Baltimore, and Dallas-Fort Worth still cannot purchase CNG at the pump using a major credit card. Recent efforts by Pickens and Multiforce suggest that California is emerging as the leader to implement open access card reader systems. This is partially due to lessons learned by companies such as Multiforce, in cities like Baltimore. Additional lessons learned in these programs, which might be helpful in crafting a government RFP, have been integrated into recommendations provided in Section 4.0.

[28] PH&H is part of Wright Express.

[29] From Washington Gas Web site (http://www.washgas.com/products/ngvguide.pdf).

## 3.0 Reliability of Card Reader Systems: Gasoline vs. CNG Stations

As previously noted, POS systems at CNG stations range in sophistication from basic to advanced card reader systems with the full features of today's retail gasoline station. Beyond the issue of credit card acceptance, some NGV users have observed that point-of-sale systems tend to be less reliable and "user friendly" at CNG stations compared to gasoline and diesel fueling stations. It is important to note, however, that these observations are primarily based on a "apples to oranges" comparison, i.e., low-throughput, low-density CNG fueling stations versus the ubiquitous high-throughput, commercially mature retail gasoline station.

Nonetheless, to further advance NGV commercialization it will be necessary to make CNG stations as reliable and user friendly as their gasoline counterparts. To address the qualitative observations noted above, ADLittle contacted dispensing-station equipment vendors and people knowledgeable about alternative and conventional fuels. The approach was to compare and contrast components for the two systems. This provides a reasonable means to systematically assess the potentials for real and perceived differences in point-of-sale reliability issues.

### 3.1 General Observations and Nomenclature

For further exploration into their potential ramifications to card reader reliability, several key nuances within the fuel-dispensing industry are briefly described below.

**Gaseous versus liquid fuel stations:** CNG stations dispense gaseous fuels. Compared to liquid fuels, such as gasoline and diesel, gaseous fuels require markedly different storage, handling, and dispensing techniques and technologies. Even first-time NGV users quickly become aware that gaseous fuels behave differently than liquid fuels when they first implement the fueling process at a CNG station.

**Commercial versus retail stations:** Commercial fueling stations service vehicle fleets operating for business purposes; they typically do not provide "public access" because they aren't intended for use by the general motoring public. Typical commercial stations include those that fuel municipal, transit, refuse, rental car, taxis, shuttle vans, and government fleets. In contrast, "retail" stations serve the general public. Essentially, all drivers using privately owned vehicles fuel at retail stations. Today's CNG infrastructure consists of both commercial and retail stations. With relatively few personal CNG vehicles on the roads, retail CNG stations are generally severely underutilized today. In contrast, commercial CNG stations with "anchor fleet" customers dispense large volumes of natural gas.

### 3.2 System Components as potential sources of reliability problems

The selection of hardware and software components for an automotive fueling station is largely dictated by the type of fuel (e.g., liquid vs. gaseous) and the primary intended user (i.e., commercial vs. retail customers). In turn, the selected components can potentially impact the reliability of fueling stations. Some of these components are directly related to the card reader system.

For a given application, CNG and conventional fueling stations mostly utilize substantially similar equipment and components. These include fueling islands, fuel dispenser cabinets, site controllers, and point-of-sale software. For the purposes of this discussion, equipment common to both conventional and CNG fuels will be referred to as "fuel neutral".

Although there is overlap in components for CNG and liquid fueling facilities, the two fuels have distinct handling requirements. Hardware and software components that differ based on these fuels can be thought of as "fuel dependent." Such fuel-dependent equipment partially consists of "analogous" components that differ structurally but are similar in function. For example, both CNG and conventional fuels require storage tanks, but they differ markedly in design, method of fuel storage, and physical characteristics. In addition to these analogous

devices, fueling stations also employ “distinct” components that are not found in counterpart stations. An example is the receiver dryer equipment installed at some CNG stations that removes moisture from pipeline natural gas before it is compressed into CNG.[30]

These nuances between CNG and conventional fueling stations are a key to understanding potential root differences in station reliability. Fuel-neutral components are the least-likely sources for differences in system robustness, at least if they are used under comparable conditions. For example, a magnetic card reader found in both CNG and conventional stations is certainly prone to some degree of system failures. However, such imperfections would be common to both types of stations and therefore would not explain differences in reliability between the two.

It is more probable that dissimilar equipment will lead to differences in system performance and reliability. This line of reasoning leads to an examination of the "analogous" and "distinct" components highlighted above. Analogous components differ in operational parameters despite their functional similarity. The operation of these units can lead to differences in overall fueling system reliability. Since “distinct” components differ in both form and function, they are possibly even more likely to be a source of reliability problems for CNG stations, compared to gasoline stations.

Figure 1 and Figure 2 outline the basic layouts of components found at CNG and gasoline fueling stations. Table 5 categorizes these station components into one of the three categories: fuel neutral, analogous, and distinct. This categorization is based on conversations with fueling station equipment providers for CNG and conventional fuels. A list of vendors that participated in these interviews is provided in Table 6.

These categorizations are based on "best case" (i.e. more integrated) products. For instance, a vendor of a certain fuel-dispensing system (or its various components) can choose to offer a product that has protocols unique to a particular fuel—but most do not. In other words, there are no definitive product boundaries,[31] as suggested in Table 5, but this breakdown does reflect common practices currently in use.

As Table 5 indicates, there are many components that are common to both types of fuel stations, and this is the case for state-of-the-art dispenser systems. Earlier in this report, it was described how Greenfield Compression manufactures and markets its CNG dispensers by upfitting Marconi’s gasoline dispensers. While there are significant differences between a conventional Marconi dispenser and a CNG unit prepared by Marconi/Greenfield, the cabinet and electronics are essentially the same.[32] This includes the standard two-wire interface that is used to communicate between the card reader controller and dispenser.

This finding is not unique to the Marconi/Greenfield dispenser; rather it is provided as a representative example of the similarity found in some station hardware for CNG and liquid fuels. Again, it is important to note that the number of CNG dispensers built and shipped to customers is a small fraction of those deployed at gasoline and diesel stations.[33]

[30] It should be noted that the line between analogous and distinct components is somewhat artificial. Virtually all components of any fueling station serve a function related to fuel delivery, storage, preparation, dispensing, or metering. An example of a gray area is the CNG compressor versus the gasoline pump; both deliver fuel, but the compressor has an essential distinct role to increase energy density.

[31] Also see footnote 30.

[32] According to the Marconi Web site (http://www.marconicommerce.com), CNG versions of its dispensers use “standard operation and communications protocols” for systems compatibility. A key difference is that CNG dispensers are designed for Class 1 explosion proofing by isolating the top area (containing the card reader and electronics) from the bottom half, which includes CNG valving and piping and a positive-flow air purging system.

[33] The U.S. GAO estimates that there are 180,000 gasoline stations nationwide, compared to about 1,200 CNG stations. Assuming on average three gasoline dispensers/station and one CNG dispenser/station, today there are about 450 gasoline dispensers in use for every CNG dispenser.

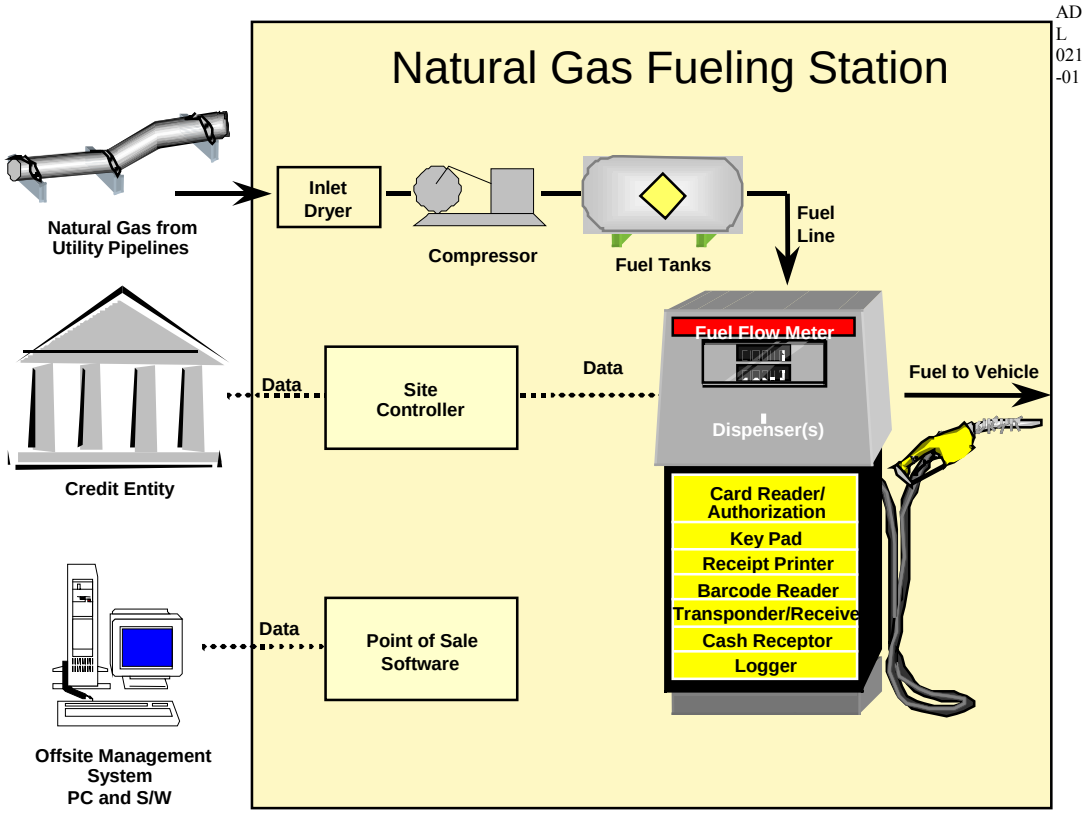



**Figure 1. CNG (Gaseous Fuel) Station Schematic**

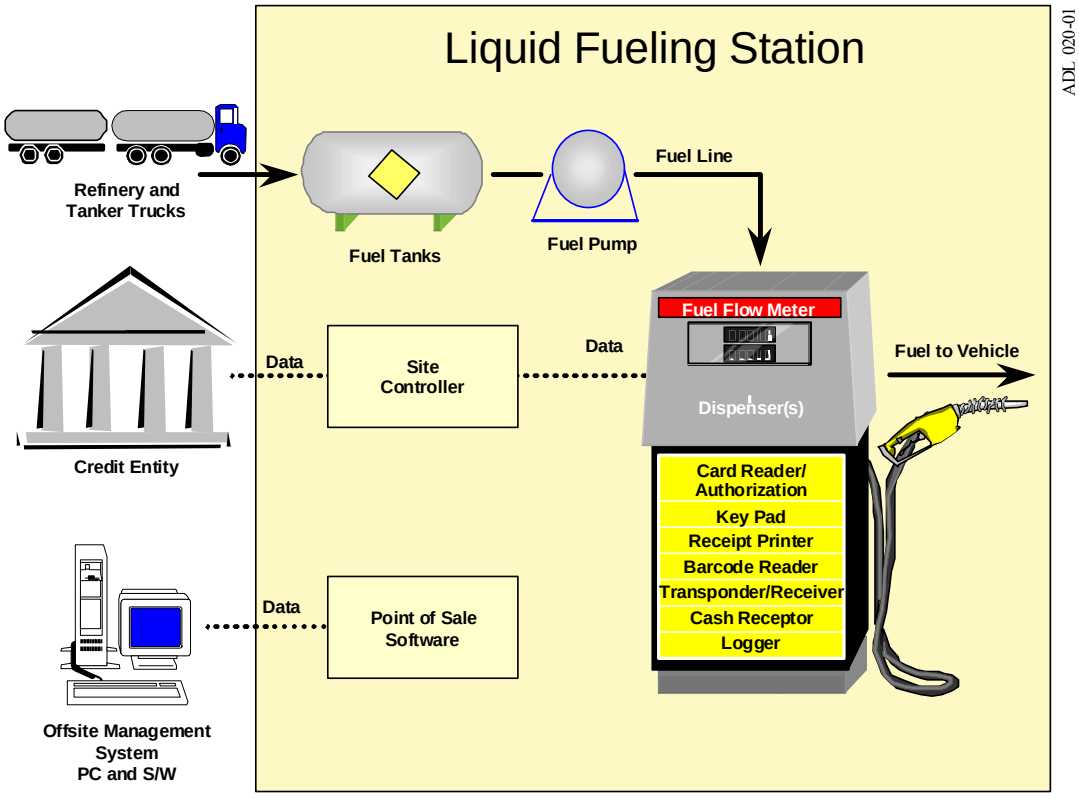



**Figure 2. Gasoline (Liquid Fuel) Station Schematic**

**Table 5. Categorization of Fueling Station Equipment and Components**

| Equipment Category | Fuel Station Type | |
|---|---|---|
| | CNG (Gaseous) | Conventional (Liquid) |
| **Fuel Neutral** | Dispenser Cabinet<br>Display Card Reader<br>Dispenser Options<br>Site Controller/POS Software<br>Credit Vendor<br>Offsite Management Tools | |
| **Analogous** | | |
| Fuel Storage | (High Pressure) CNG Tank (Vessel) | (Ambient Pressure) Liquid Tank |
| Flow Metering | Coriolis | Positive Displacement |
| Fuel Handling | Gas-Compatible | Liquid-Compatible |
| Fuel Delivery | NG Compressor | Fuel Pump |
| **Distinct** | | |
| Fuel Conditioning | Inlet Dryer<br>Coalescing Filter | |

**Table 6. Fueling Station Industry Sources Contacted and Results**

| Vendor Contacted | Result |
|---|---|
| AutoGas | Input Provided |
| E.J. Ward, Inc. | Input Provided |
| Greenfield Compression, Inc. | Input Provided |
| Marconi Commerce Systems | Input Provided |
| Multiforce Systems Corporation | Input Provided |
| Pickens Fuel Corporation | Input Provided |
| Voyager/U.S. Bank | Input Pending |

The focus of this discussion is on reduced reliability of CNG stations specifically related to card reader systems. However, it is also important to take a "systems perspective," including examination of CNG station components that are "upstream" of the card reader. Key components include the following.

**Station fuel tanks:** Storage tanks for liquid and gaseous fuels are built around the requirements of the fuels they support. Liquid fuels are generally stored at atmospheric pressure in underground tanks and pumped to dispensers. CNG at typical fast-fill stations is stored in above ground tanks at (most commonly) 4,500 psi. The size of the storage tanks and the quantity of fuel that must be stored on site are also quite different (considerably less CNG is usually stored on site compared to gasoline or diesel fuel). While CNG storage and delivery systems have sometimes exhibited performance limitations (e.g., slow or incomplete vehicle fills related to fuel pressure and thermal dynamics), there are no obvious reliability concerns with CNG tanks versus liquid fuel tanks. As long as CNG tanks meet pressure vessel standards

and are reasonably maintained, there are no inherent factors involving the tanks that lead to an inability of obtaining fuel when fueling cards are inserted into the card reader.

**Fuel flow meter:** Dispensing of liquid or gaseous fuels–especially at retail stations–requires relatively precise fuel metering to complete the sales transaction. For liquid fuels, several metering technologies are available; positive displacement flow meters are one of the more common methods. Flow meters for gaseous fuels like CNG are functionally identical but typically use different measurement techniques. One of the most widely used meters in CNG dispensing is the Coriolis mass flow meter.

As their fuel metering techniques differ, CNG and conventional fuel dispensers also have somewhat unique electronic interface between the meters and the balance of the system. However, many dispensing systems are explicitly designed to accommodate these different types of meters and electronic interfaces. In California, all fuel meters are subject to approval and calibration by County Weights and Measures Offices—as extensions of the California Department of Consumer Affairs—to be certified for use in the sale of fuel. When all of these factors are accounted for, there is no substantive difference between gaseous and liquid fuel metering systems that would impact system performance or reliability.

**Fuel handling hardware:** Handling hardware such as hoses and nozzles can also be significantly different for gaseous fuels like CNG compared to liquid fuels like gasoline. While no reliability data are available for liquid and gaseous fuel handling systems, vendors have strong motivation to minimize fuel leakage and other potential problems due to concerns for safety and station profitability. One problem that has occurred at some CNG stations is the icing of nozzles on a natural gas vehicle's fuel inlet when it's being fueled. However, such problems are being improved with new station equipment technology. There appear to be no significant issues or problems with CNG handling equipment that significantly hinder customers from obtaining fuel.

**Fuel delivery equipment:** The natural gas compressor is one major difference between CNG and liquid fueling stations. CNG compressor systems are significantly more expensive and complicated than liquid fuel pumps. With many moving parts, rigorous duty cycles to compress natural gas to high pressures,[34] and demanding maintenance requirements, CNG compressors can be weak links in station reliability. Clearly, they have more potential failure modes than liquid pumps. The importance of such "upstream" failures to perceived card reader reliability will be discussed.

### 3.3 Market and Business Factors in System Reliability

Several potential weaknesses in CNG station reliability relate directly to market pressures and business decisions. These include inter-related technical, fiscal, and organizational factors.

**Low-bid Syndrome:** Unlike retail gasoline fuel stations, many CNG stations have been funded through government-subsidized programs. These installations have often been awarded to the lowest bidder through government solicitations that only require meeting minimum performance standards. The result has been deployment of many CNG stations unable to reliably provide fuel to NGV users, for problems generally related to 1) poor equipment quality, 2) poor systems integration, or 3) lack of proper operation and maintenance procedures.[35]

Card readers may be the least likely cause of fueling failure at these problem stations. However, customers are not likely to know why a particular CNG station is non-operational. Moreover, the card reader is unlikely to provide this information. Thus, being the point of customer interface, the card reader

[34] The cost of CNG compressors and the number of required compression stages are largely a function of station capacity and the available pipeline pressure for a given station.

[35] These types of failures should decrease in time as experience is gained, product quality is improved, and the CNG business increasingly becomes focused on high throughput facilities owned and operated by turnkey CNG providers.

may be assumed to be the problem, for lack of better information. This important point is discussed further below.

**Low-volume Manufacturing:** Liquid fuel dispensers are generally manufactured in a few modular, standardized models to achieve higher production volumes and lower cost. Moreover, liquid fuels themselves are currently sold in much larger volumes than CNG, enabling cost-effective production of higher-quality dispensing equipment. Also the competition for consumer retail business generates additional pressure to make high-quality products in the gasoline dispenser business. CNG dispensers are typically "upfitted" from gasoline dispensers in relatively low volume (e.g., the Greenfield Compression/Marconi arrangement). It is reasonable to assume that there is a greater potential on a percentage basis for quality control problems to occur while manufacturing CNG dispensers. However, no data are available to corroborate this.

**Relative costs of dispensers:** CNG dispensers cost more than liquid dispensers, in part due to the higher cost of special components,[36] and also due to the low-volume sales noted above. The elevated costs of CNG dispensers can force other sub-systems to receive smaller allocations than otherwise advisable. The result may be procurement of lower-quality hardware that is nonetheless critical to system reliability.

**Customization of CNG stations and components:** It is well documented that CNG stations tend to be highly customized installations due to site- and vendor-specific parameters. Dispensers and card reader systems are actually among the more standardized components of CNG stations, unlike compressors and other system components. Still, more system customization means less industry-wide familiarity with a particular design, and the potential for increased frequency of failures—ultimately that may be attributed to the card reader system.

**Number of dispensers:** Today's typical public access CNG station features one or two fuel dispensers, with one to four hoses in total. By comparison, at a typical urban gasoline station, there may be as many as 18 pumps dispensing fuel. Unlike the CNG case, if such a station has a malfunctioning dispenser, several other dispensers are likely to be available. This can result in increased station-wide reliability via redundancy; it also decreases the likelihood that a driver will be stranded due to lack of fuel. The more dispensers that are at a facility, the lower the probability that the fuel-buying public will leave the station without fuel, concluding that a station reliability problem exists.

### 3.4 Summary of Potential Factors Affecting CNG Station Reliability

As previously described, there are many factors that play a role in achieving good reliability for fueling stations. These include equipment and component failures as well as business and market factors. Shortcomings in reliability stem, in part, from non-technical decisions. For instance, choosing poorly supported products or lower-quality equipment due to inexperience with CNG dispensing can explain some of the reliability issues experienced by NGV users when fueling with CNG. Also, conventional fuels are dispensed in significantly larger volumes that enable investments in larger stations with more features to be recovered in a cost-effective manner. As such, conventional stations can afford to invest in top-quality equipment.

It's also important to note that CNG stations have broken into the commercial marketplace during a relatively short time period. More than a century ago gasoline stations began dominating the transportation fueling market as simple systems that reliably pumped fuel but offered few of today's modern conveniences. To evolve into today's fully automated station with sophisticated, pay-at-the-pump card readers, gradual iterations in hardware and software technology were incorporated over many

[36] For example, Gilbarco's Advantage Series gasoline dispensers use "standardized assemblies" designed for ease of servicing with "no special blending hoses or nozzles" required, while the CNG version uses significantly more expensive, customized components.

decades. CNG stations also entered the transportation market as simple, highly reliable fuel-delivery systems. However, since then, their evolution from manual valves and controls into automotive-style stations (card readers, dispensers with pressure compensation, and accurate metering devices, and a host of other automatic systems) has taken place in less than two decades. Much of the electronics-related sophistication for CNG stations has emerged within the last few years. Adding many complex components at once to a commercial product without gradual evolution can initially lead to higher failure rates. Sometimes, when new technology is rapidly deployed to enhance consumer utility and friendliness, reliability may be sacrificed.

The fueling processes at gasoline and CNG stations are both dependent upon successful execution of a specific sequence of events. While much of the equipment and components are identical (or essentially the same), the CNG fueling process currently requires more steps involving more components and equipment. Both factors can result in decreased system reliability because more complex operations generally have more potential failure modes.

However, there is insufficient information to assess the specific role of card reader systems in reduced CNG station reliability. Based on the track record of more common gasoline systems, it is believed that card readers themselves can be among the most reliable parts of CNG systems (though no data are available to corroborate this). Since most CNG users interact only with the station's customer interface (i.e., the dispenser/card reader), it is possible that this interface is erroneously viewed as "less reliable" when system failures occur. Unlike gasoline stations, CNG stations are often unattended and therefore may not offer up-to-date notification to customers about problems. As a result, the customer may go through all the motions of swiping an appropriate fueling card and punching in the required information only to finally learn that fuel is unavailable. For such cases, the card reader may be blamed for a malfunction elsewhere in the system. While this argument is obviously speculative, it is worth recalling that customers tend to interject their experience on the interface. This does not dismiss the possibility of CNG card reader systems having decreased reliability relative to their gasoline counterparts. However, it's possible that user observations have been based on incomplete information or inaccurate perceptions.

## 4.0 Results: Recommended Specifications for Government RFP

The key deliverable of this task order is to develop a draft set of requirements to be included in a solicitation for the design and development of a reliable, open-architecture, card-access system that can be implemented statewide and, eventually, nationwide. Based on information gathered for this report, it is clear that significant advancements are already being made toward this end. However, there is a compelling argument that government assistance is needed now more than ever. There is ample evidence suggesting that–while the *technical* capability appears to readily exist for the processing of mainstream credit cards at public-access CNG stations–it is not yet an economically practicable option--at even the most advanced collaborations between fuel providers and the fueling card industry.

This report focuses on CNG stations because most of the nation's recent AFV experience has been with CNG vehicles. However, its findings and recommendations also generally pertain to the emerging fueling networks of other alternative fuels. Thus, the lessons learned from the CNG station experience can help displace greater volumes of gasoline and diesel with a variety of non-petroleum transportation fuels. This includes the longer-term use of hydrogen, which faces many of the same infrastructure-related issues as CNG and will be needed for fuel cell vehicles that are expected to gradually begin penetrating the transportation market later this decade.

### 4.1 Matrix of Requirements

Using information obtained from the three main sources identified in this report–the workshop on March 16, 2001, private discussions with vendors and station site visits, and lessons learned from other similar programs across the United States—ADLittle and Fuel Solutions have developed the following draft set of requirements.

Five types of functionality are needed in a fuel management system for alternative fuel stations to truly offer "open access" to fleets and the general motoring public. These elements, listed below in Table 7, provide a functional (performance) standard that can be included in a government RFP.

**Table 7. Necessary Elements of Fuel Management System Functionality**

| Key Element | Description |
|---|---|
| The ability to distinguish between anchor and outside fleets | • Since stations will continue to be built primarily to fuel one or more anchor fleets, a means of identifying anchor fleet users is needed to allow vendors to offer preferential pricing or provide direct connection to the anchor fleet's management information system. |
| The ability to accept Voyager or other fuel-network cards for fleet transactions | • CNG fleets tend to be concentrated in the public sector, and the Voyager card has become a preferred fleet card (e.g., federal GSA, State of California). Consequently, Voyager has become the closest thing to a universal fuel network card that could be used by traveling CNG vehicles. Voyager has worked closely with FuelForce to develop the technical and administrative systems for nationwide acceptance of Voyager at CNG stations. The capability to accept competing fuel network cards, such as Fuel Man, is needed for stations that may serve more customers using these networks. |
| Means to enter and validate odometer readings | • This feature is often required by managers of many fleet types. |
| The ability to accept bank credit cards. | • The ability to accept bank credit cards, such as VISA, MasterCard, and Discover, is critical for encouraging the growth of personal CNG vehicle use by private parties. Bank card acceptance is also needed to serve certain fleets, such as taxis. Taxi drivers are owner-operators in a business characterized by high turnover and spotty creditworthiness. Fueling networks cannot afford to establish credit for such fleets. Bank credit cards are the only practical billing means for these fleets. An open FMS must be capable of accepting bank credit cards.<br>• A few CNG fuel management systems are currently configured to accept bank credit cards. Because of the small size of the NGV customer base, bank credit card transaction fees at these stations are high–between $1.50 and $2.50 per transaction. The FMS must be capable of alerting customers of these fees prior to the transaction and then properly add the fee to the customer fuel bill. |
| Ability to verify customer training | • Many CNG stations are unattended. Vendors want to minimize liability and maximize safety by verifying that customers are trained in CNG dispensing. This could help reduce the fuel provider's liability in the event of a mishap. Marking fueling network cards with CNG authorization codes, and the FMS refusing service to uncoded cards, would be one way of implementing this feature. |

## 4.2 Anticipated Steps Needed by Prospective Contractors

### 4.2.1 Universal Card Reader Access

A number of steps must be taken for prospective bidders to develop and deploy card reader systems that meet the five types of functionality identified previously, and address the various barriers discussed. Examples of efforts that are anticipated to be necessary are:

1. Purchase and install hardware.

2. Commission and test hardware.

3. Develop software, e.g.:

- Prepare code and communication algorithms to communicate back and forth from the network card authorizer for each type of card to be accepted.
- Enable differentiation of each card type taken at the card reader using customized protocols.

4. Configure and set up the site on the host computer located in the fuel provider's office.

5. Perform all steps necessary to ensure that the site is properly set up and functional, e.g.:

- Ensure that the card reader, once it is live at the site, is able to communicate with the host computer at the fuel provider's office.
- Ensure card reader is authorizing each type of proprietary card to fuel properly.
- Ensure that the transaction is correctly being read by all computer linkages.

6. Provide mechanism to reasonably verify that fuelers have received proper training.

7. Provide at-the-site quality control and troubleshooting to address problems, e.g.:

- If card reader at site is not properly connecting to the modem at the host computer.
- If the transaction information at the site differs with the transaction information at the host computer.

8. Select network (e.g., Payment Tech, ByPass, ADS) to serve as a centralized clearinghouse to hold credit information of cardholders.

9. Develop a work and communication plan (from the software provider) that is presented to the network and approved by the network.

10. Perform offline testing and troubleshooting at the beta test site (after code is written, presented to the network and approved).

### 4.2.2 Card Reader Reliability

Gasoline-equivalent reliability of card reader systems for CNG stations should be among the many priorities captured in government-funded station procurements. One important control for the purchaser of CNG systems requires no special specifications–that is, selecting companies with a proven track record

in building state-of-the-art fuel, durable dispensing systems and card reader systems. In the absence of specific durability data and testing protocols, it is recommended that government RFPs for CNG stations include basic language requiring bidders to fully describe 1) the components of the CNG dispenser and card reader systems, 2) how they are manufactured (e.g., upfitted from conventional systems) and by whom, and 3) how they differ from conventional systems. Vendors should be asked to provide details about their quality control plan to provide CNG card readers and dispensers with equivalent reliability to gasoline systems.

(Perhaps suggest that RFP evaluation criteria include a list of successful similar systems that the prospective vendor has implemented elsewhere before, along with references of past customers that can be contacted. I would think that info obtained along these lines should be weighted heavy enough to balance the low-bid syndrome mentioned earlier in the report).

### 4.2.3 Recommendation for Two Types of RFP

Based on feedback obtained during the workshop and discussions with individual companies, the ADLittle/Fuel Solutions team recommends that NREL and its government partners develop an RFP divided into two distinct procurements designed to seek development and demonstration of the following:

1) New natural gas fuel management systems having the features described above (to include real-time transaction authorization with Voyager and selected credit cards).

2) Retrofit equipment to upgrade existing fuel management systems to have the features described in item 1, above.

To foster competition between suppliers of commercially available systems presumably resulting from this demonstration, multiple contracts in both procurements could be awarded. Criteria for award in the first procurement should include:

- Extent of the proponent's existing market for fuel management systems.
- Technical merit of the proposed approach.
- The range of cards (beyond the core required cards) that the system could accommodate.
- The amount of leverage that the project will bring from previous or ongoing development efforts.
- Submittal of a suitable business plan or path to commercialization for system to be deployed/demonstrated.
- Potential to deploy the system at stations dispensing other alternative fuels and stations outside of California.

These same criteria could also apply for the retrofit procurement. However, the applicability of the proposed system to the largest number of existing CNG fuel management systems, at the lowest possible cost, are clearly important criteria, as well (e.g., cost effectiveness of retrofitting 20 sites).

Once viable systems for upgrading existing fuel management systems are demonstrated in the planned procurement, it would be worthwhile to fund follow-on work to install successfully demonstrated systems in a number of existing fueling stations and validate their performance in use.

## 5.0 Appendix A: Presentation at March 16, 2001, Workshop

# Workshop to Discuss Open-Architecture Card Access Systems for Alternative Fuel Stations

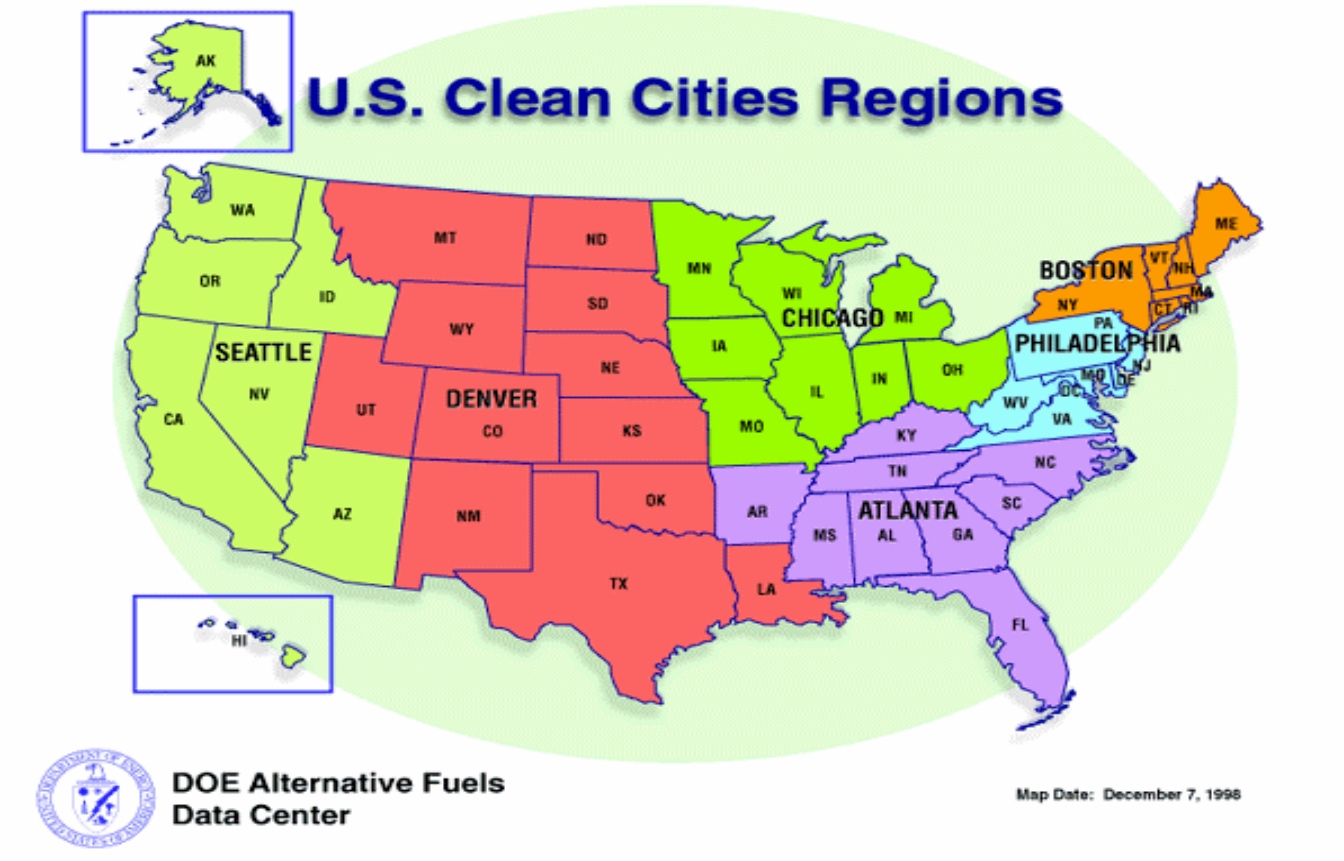
**Sponsored by:**
**NREL / DOE (in conjunction with CEC and AQMD)**

**Prepared by:**

**Arthur D. Little, Inc.**
**and**
**Fuel Solutions**

**March 16, 2001**
**Diamond Bar, California**


**ADLittle and its partners (Fuel Solutions and The Research Partnership) have been selected by NREL as one of several "Tiger Teams" to support AFVs and infrastructure, in association with the Clean Cities program**

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## Task Order #1 for ADLittle Team:

- **Task Order Name:** Open Architecture for Card Access to Dispense Alternative Fuels
- **Task Order Team:** Arthur D. Little and Fuel Solutions
- **Objective:** define a set of requirements to be included in a government solicitation for development of a card reader architecture that can be used "universally"
- **Task 1:** Plan, coordinate and facilitate today's workshop
- **Task 2:** Complete further research and fact-finding to define issues and barriers
- **Task 3:** Deliver (to NREL / DOE) a draft set of requirements for the design and development of a card access system for implementation statewide, and eventually nationwide
- **Task 4:** Incorporate modifications and submit final requirements
- **Completion timeline**: 2 to 3 months, total

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# Mission Statement:

- Assist with enabling NGV users in California to fuel at sites outside of their native network, using a single card (customer driven)
  - Authorize transaction
  - Payment processing
  - Assurance for fuel provider that customer has been trained
- System should be adaptable nationwide, for all alternative fuels

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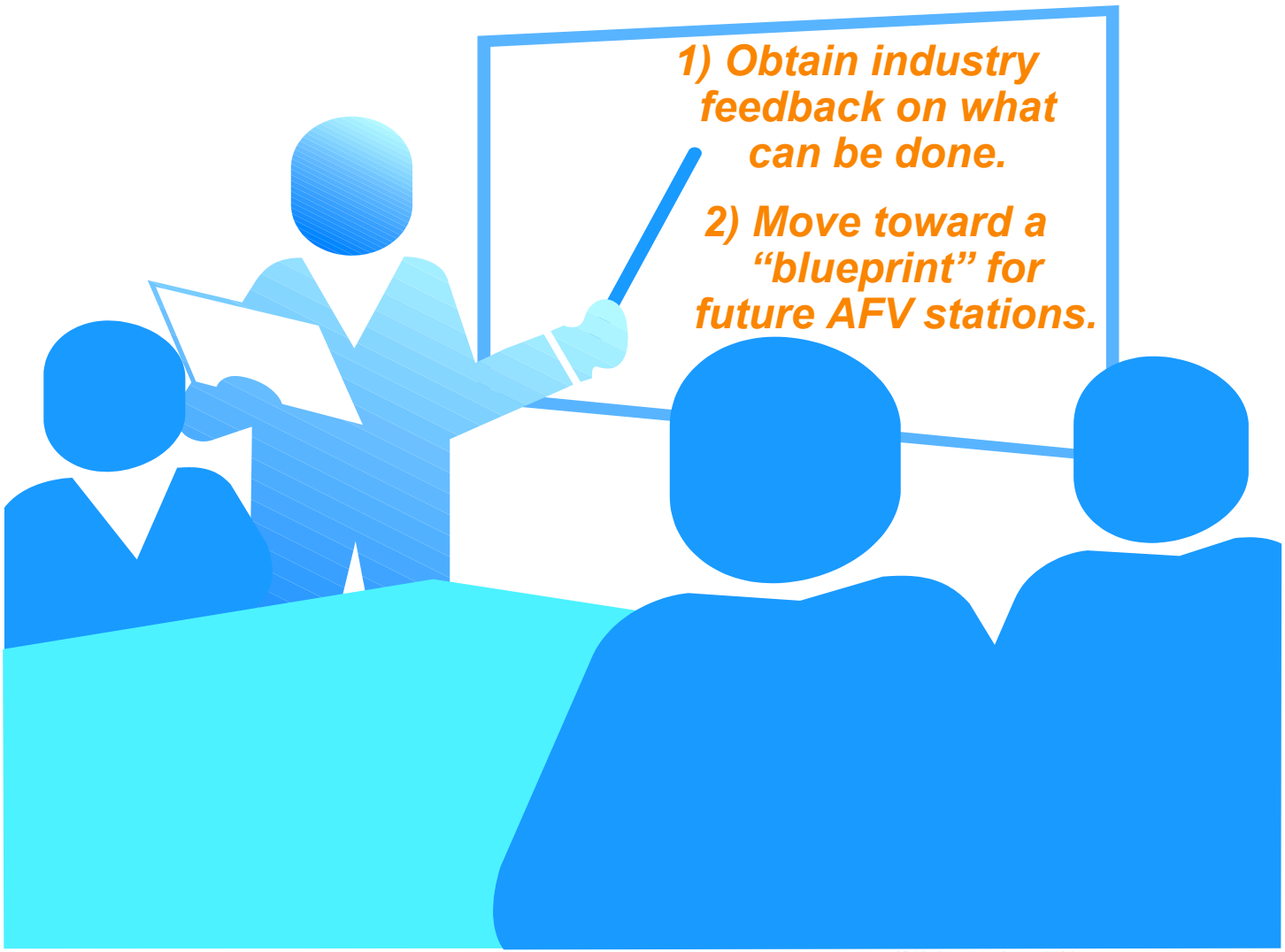
# Purpose of Today's Meeting

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# The Players are Many and Varied . . .

- **Fuel Providers:** Pickens, Pinnacle, Trillium USA, FleetStar, Blue Energy, etc.
- **Utilities:** SoCal Gas, PG&E, SDG&E, Long Beach Gas, etc.
- **Card Reader Vendors:** Multi Force, Auto Gas, EJ Ward, Tech 21
- **Intermediary Networks:** ADS, Bypass, Payment Tech, etc.
- **Fleet Cards / Credit Cards:** Voyager, Wright Express, VISA, Mastercard, AMEX, etc.
- **Banks:** First of Omaha, Concourse, etc.
- **End Users:** U.S. gov't fleets (Post Office), State fleets, transit, refuse haulers, municipalities, large RTB fleets, individual motorists, etc.

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# Previous and existing related efforts / progress

- **Nationwide: FuelNet effort in Atlanta, other cities in conjunction with DOE**
- **CFN model used by independent fuel retailers**
- **Vendor interaction with Cal NGV Coalition (e.g., Auto Gas, EJ Ward)**
- **Ongoing collaborative efforts by Pickens and Multi Force**
- **Other efforts**

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## Status for point-of-sale CNG systems in the western region

**Currently, it would take as many as 10 cards to access all public CNG stations**

**Existing collaborations in California / Arizona include . . .**

| CNG Industry Entity | Current Point-of Sale Options |
|---|---|
| Pickens Fuel Corporation | ♦ EJ Ward and Multi Force (California), Autogas (Arizona) |
| Trillium USA | ♦ Autogas, EJ Ward, Visa, MasterCard |
| FleetStar | ♦ CFN |
| The Gas Company | ♦ EJ Ward |
| PG&E | ♦ Tech 21 |
| Pinnacle | ♦ Pinnacle Card |
| Source: survey input in mid 2000 | |

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# Breakdown of card options for California's public access CNG stations

| Payment Option | Number of Stations Accepting (as of November 2000) | % of Public Access CNG Stations in California That Use Payment Option |
|---|---|---|
| SoCalGas Card | 38 | 36.2% |
| PG&E Card | 27 | 25.7% |
| SDG&E Card | 8 | 7.6% |
| Long Beach Gas Card | 2 | 1.9% |
| Oil Company, Major CC or Cash | 7 | 6.7% |
| FleetStar or CFN Card | 8 | 7.6% |
| Pinnacle Card | 5 | 4.8% |
| Pickens Fuel Corp Card | 1 | 1.0% |
| Trillium USA Card | 1 | 1.0% |
| "By Arrangement" | 6 | 5.7% |
| "Any California CNG Card" | 2 | 1.9% |
| **Totals** | **105** | **100.0%** |

Source: California NGV Coalition website (http://www.califngv.org), list of CNG stations

# In a perfect world (starting with California) . . .

**AFV fueling stations will mirror gasoline and diesel stations, and**

- **Station vendors / fuel suppliers**
  - **will maintain their unique relationships, incentives, brand identity and pricing structures with best customers (anchor tenants)**
  - **can offer affordable "universal" access to retail customers without disproportional credit risk**
  - **will have a mechanism to ensure users are trained, and liability risks are managed**
  - **don't compromise proprietary databases or systems**
- **Large government AFV fleets**
  - **can use a single card at any fueling station, for various fuel types**
  - **can obtain full electronic tracking of fuel purchases and other data**
- **Small fleet users and individual AFV owners**
  - **can use a single credit (or debit) card at any station**
  - **cannot refuel unless training can be verified**

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## CEC Alternative Fuels Infrastructure Program Opportunity Notice

- Issued in February 2001
- Proposals due March 21, 2000
- $3 million available in grant funding now
- About $3 million more to follow soon

> "Funding for electronic point-of-sale equipment shall have universal capability (i.e., must accept Voyager, Visa, Mastercard and other proprietary cards where applicable) . . . ."

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# General characteristics of existing card reader systems

| Application / Type of Fueling Station | General Characteristics |
|---|---|
| Private fleet facility | Drivers or vehicles are issued ID cards or transmitters. Driver is not billed, but a company account or division is charged. Odometer data usually tracked. |
| Fueling network-owned facility serving one fleet | Fueling network verifies ID of the fleet and bills fleet monthly. Odometer data usually tracked. No provision exists to serve other fleets or private customers. No need to verify account status. |
| Fueling network-owned facility serving multiple fleets & private customers | Driver accounts are verified and billed by site controller communicating with a host database. All users typically hold a card issued by the fueling network owner. Fueling network owner bills card owners monthly. Outside fueling network cards and bank credit cards are usually not honored. |
| Public Fueling station | Customers may use cash, company credit card (e. g., Chevron), cooperating private fueling network cards (e. g., Fuelman & Voyager) or a variety of bank credit cards. Outside fueling network or issuing bank makes payment to station owner & bills their customers for transaction. An account consolidator may act as middleman between group of station owners and bank card issuers. |

## Limitations and issues with existing fuel management systems

- CNG industry is now entrepreneurial, while remnants of utility-run systems remain
- Many card readers evolved from fleet management systems, and weren't designed to bill retail AFV users
- Many are oriented to serve a single client fleet using
  - in-house card keys or ID number
  - a private fueling network card, e.g., Voyager, Pickins, PG&E
- These systems may deny fueling access to "outside" vehicles, e.g., Voyager can't be used in an EJ Ward card reader
  - results: lost fuel sales opportunities, reduced NGV mobility & driver convenience
  - limits the appeal of an NGV / AFV as a personal vehicle option
- Denies access by client fleet if fault with primary billing system
  - damaged card or billing host down
  - no access to back-up billing mechanism (e. g., VISA)

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# Barriers to “universal” access include . . .

| | |
|---|---|
| Technical | Hardware & software incompatibility |
| Financial | Unwillingness to assume risk for customers with unverifiable credit credentials |
| Confidentiality | Access may entail sharing of confidential customer data |
| Business & Marketing | Perceived risk of loss of customer sales to competitors |

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# Specific technical barriers include . . .

| Category | Example |
|---|---|
| Incompatible card readers or other means of customer identification | Bar code readers vs. magnetic stripe readers vs. vehicle information transmitters. Reader or site controller may not recognize the outside card's ID number format. |
| Communications | Sites lack telephone, data lines or compatible modem to communicate with outside databases for customer authorization and transaction logging. |
| Software & hardware architecture | No "canned" software exists*. Systems are often configured to work within a single fleet management software system environment - incapable of communicating with outside systems to authorize or record transactions. |

*** Advancements are being made by at least one vendor, however.**

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# Specific financial barriers include . . .

| Category of Barrier | Example |
|---|---|
| Establishing customer credit | Verifying creditworthiness and establishing credit for individual fuel card holders is expensive. Some issuers require individuals to maintain a deposit on account. Cards with deposit images are also used. |
| Access to bank credit and credit cards | NGV fueling networks are too small to transact directly with VISA & MasterCard. A consolidator (e. g., Payment Tech, NDS) would have to be retained, to bundle enough accounts for banks to be interested. |
| Serving outside fueling network card holders | Outside fueling network must a) enter into agreement w/ station owner to honor debts of anyone using its card, or b) allow owner access to its database to verify card status. |

# Specific confidentiality issues include . . .

- Credit card issuers generally require verification of account status as a condition for payment for goods or services
  - Equipment & protocols must be installed for the fueling station site controller to communicate with the issuer's account database
  - Required characteristics include:
    - reliable
    - secure
    - does not download or permit unauthorized access to confidential account data
- Proprietary cards each involve a separate database. Data sharing may require explicit permission by every account holder
  - this may work in some cases (e. g., PFC access to the Socal Gas NGV fueling account database), but . . .
  - Competitors sharing databases is an entirely different issue

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## Specific business and marketing considerations include . . .

- Fuel providers want to retain ability to give special rates and/or services for anchor tenants and special customers
- NGV fueling networks now generally enjoy separate geographic territories, but in the future they may compete for the same area
  - This may create reluctance to honor each other's cards, i.e., why cooperate if it results in losing a sale to the guy across the street?
- This principle appears to operate in the case of petroleum company credit cards
- As with petroleum fueling stations, this issue should be resolvable by giving access to a variety of third party cards (e. g., Voyager, FuelMan and bank cards) with no ties to a particular fueling network

## Other considerations include . . .

- Unlike gasoline customers, CNG users need training for refueling procedures and safety (at least until NGVs are commonplace)
- It's currently not feasible to maintain on-site staff at many CNG stations (even public access)
- Therefore, automated mechanism needed to:
  - Query customers on training, and lock out fueling without verification
  - Minimize liability for the fueling station owner / operator
- Does any mechanism currently exist?
- If not, how difficult / costly will it be to deploy card reader systems that can transact from mainstream cards and still "lockout" untrained users?

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# Summary

- Compared to conventional petroleum infrastructure, the convenience and availability of NGV infrastructure (and AFVs in general) is poor
  - This limits NGV fleet growth & fuel sales
- Government stakeholders wish to cooperate with industry to demonstrate NG fuel management systems that are
  - Based on open/conventional hardware & software platforms
  - Inter-operable and user friendly
- Today's "workshop" is an initial step towards that process
- We hope to learn how the industry can move forward with a system to use third party fueling network cards and bank credit cards to achieve improved customer convenience.
- Based on input received here today, and during follow-up interviews / site visits, the ADLittle team will develop a set of requirements that NREL and other government agencies can use in a near-term RFP.

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